exploiting the seas

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In the opinion of many engineers, Lockheed Aircraft Corporation has one of the best corporate noses for ferreting out and effectively, as well as profitably, exploiting new technologies in a multitude of fields, and that the corporation's normal tendency is to involve itself to the outermost limits of those technologies.

I am one who holds this opinion. Therefore, when some time ago I was part of a group permitted to inspect the competent, submersible Deep Quest which Lockheed had built with Corporate funds, I questioned the combination of advanced and ancient technologies in this fine workboat.

For example, the structural spheres which made up the living quarters for underwater passengers, protecting them from the extreme pressures, were strictly tomorrow's technology, but the energy source used to provide power closely resembled an automobile battery—definitely today's technology.

When I questioned this, the reason for the dichotomy was explained: Lockheed used advanced structural designs so that the boat would meet specs at extreme underwater pressures. The well-established lead–acid battery provided the boat with all the power it needed for its projected tasks.

The lesson? For underwater use, provide your system with the best possible components and the capacity to fully perform the tasks assigned, but all technology more advanced than necessary should be excluded.

Lockheed employed the very best structure in building the work boat in order to meet depth specs. A strictly state-of-the-art power supply was selected because Lockheed needed no better. Had Lockheed done otherwise, in today's jargon, the boat would not have been cost-effective—and costs underwater are paramount.

A more careful look at power requirements for an underwater work boat includes propulsion, electronics, illumination and station-keeping. To engineers acquainted with aeronautics and astronautics, or with ground or water-surface transportation, propulsion automatically is provided the lion's share of the energy. Since current underwater work boats have propulsion power requirements that are nominal at most, their total energy needs are, therefore, relatively modest.

Today's submersible work boats most often are launched from a surface platform that is positioned beforehand in the vicinity of the work area. The little work boat then travels to its target area using a mode of motion closely resembling that of an elevator. True, needs exist for maneuvering, etc., and drag underwater is a few orders of magnitude greater than in air, but the distances travelled are usually measured in terms of but a few nautical miles and speeds of no more than a few knots. Overall, this is achieved with modest energy expenditures which the lead–acid battery can handle. A few horsepower output for propulsion and a more-or-less equivalent amount for other outboard and inboard needs fulfill the total bill, nicely.

Indeed, there are organizations which are betting that Lockheed actually erred when it chose a technology as advanced as lead–acid batteries to power Deep Quest, on the assumption that this power source is overly expensive for the power needed by a work boat. Noting, too, that these boats act prmarily as elevators and also require surface support ships, they are supplying power to their boat from an attached overhead electrical cable energized by a simple oil-powered surface generator. Lockheed counters by noting that the Deep Quest boat is designed to descend to an 8,000 foot depth where such cables are neither effective nor inexpensive. Presently, the lion's share of need for underwater boats is over the continental shelves where depths are at least a magnitude less than the capability of Deep Quest. Underwater work boats with power supplied by cable are now making their appearances and, for various reasons, will probably pre-empt the more sophisticated boats in this work area.

One can predict that this situation of mimimal underwater capability will eventually change and energy sources with larger capacities will be needed. It seems curious that most studies addressing this subject take the tack that only the highest energy, esoteric types are worthy of consideration. Most such studies suggest that nuclear energy or, at least, fuel cells be developed for use underwater.

An example of a limit to which this approach has been taken is the preliminary development of an underwater source of heat for use by swimmers operating in cold waters, in which a radioactive isotope is encapsulated in a shielding material and the heat output result from its spontaneous decay used to warm water supplied to tubes embedded in an undergarment worn by the swimmer. The Navy while pleased with the concept of heating with warmed water, is leaning towards the use of heaters based on chemicals and costing a small fraction of the estimated tens of thousands of dollars per unit required with the radioisotopes. While the totally amortized costs of the radioisotope over its many potential years of service (assuming it is not at sea) might even be less than that of the chemical heater, its capital expense places it entirely out of the limits of acceptibility for use underwater.

One compelling reason for the almost universal consideration of nuclear energy types for use in future underwater schemes is the wonderfully effective nuclear submarines now in service by the Navy. Another is the absence underwater of an environmental oxidizer whose effectiveness approaches that of oxygen in air. Simple thermodynamic calculations show that certain metals when reacting chemically with free water provide fair energy outputs, and aerospace rockets routinely carry bot' fuel *and* oxidizer. Before Navy subs went nuclear, studies were made which indicated that serious consideration should be given to powering subs by essentially the same energy supply now used to launch man into space: diesel fuel and liquid oxygen. The total argument showed that stealth need not be comprised by doing so, and it became especially potent when development and on-station costs were considered, along with the fact that submarine missions are limited by crew endurance and not horsepower-hours of stored energy.

Certainly, the distant future will see many desirable applications of nuclear energy to support man in the undersea environment. Meanwhile, perhaps the old studies should be dusted off, up-dated, and their conclusions impartially debated. Undoubtedly, underwater economics will dictate that this be done—soon. Then (who knows?) the spate of papers now being written, which propose only nuclear energy for propelling the large transport subs of the future or for supplying energy for future underwater habitats, might be superseded with others relying on chemical energy. Possibly, even those papers now suggesting fuel cells will take a back seat.

A brief look at fuel cells reveals a technology with high popular impact: chemical energy transformed directly into electrical energy—the type often most conveniently used—without moving parts and potentially at very high efficiency. One can ask whether this is a technology for tomorrow or for a more distant future, with respect to the undersea world. It is only hydrogen and oxygen as chemical sources that now provide neat theoretical outputs in practical hardware, but they do so only when operation is at certain power levels. Hydrogen is not simple to store, either as a cryogenic liquid or high pressure gas. For such reasons, it may prove prudent to look into other methods to supply energy underwater.

Present technology has resulted in many heat cycles which operate at efficiencies almost competitive with that of fuel cells, even when an electrical generator is included. The myth of continuously recurring problems when rotating parts are involved in a power plant has been effectively dissipated by actual hardware lives of tens of thousands of hours. Heat engines can use many fuels which are not adaptable to fuel cells. With such credentials, and considering the cost-effectiveness requirements of underwater systems, I, for one, would not want to bet on fuel cells in competition with heat engines.

In short, the power engineer seeking employment, or projects, related to underwater technology should carefully consider practicalities: the need is for the system that is the most cost effective—no excess fat can be tolerated.

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